

# LEARNING FROM INDUCED SEISMICITY IN THE DALLAS FORT WORTH AREA

Brian Stump

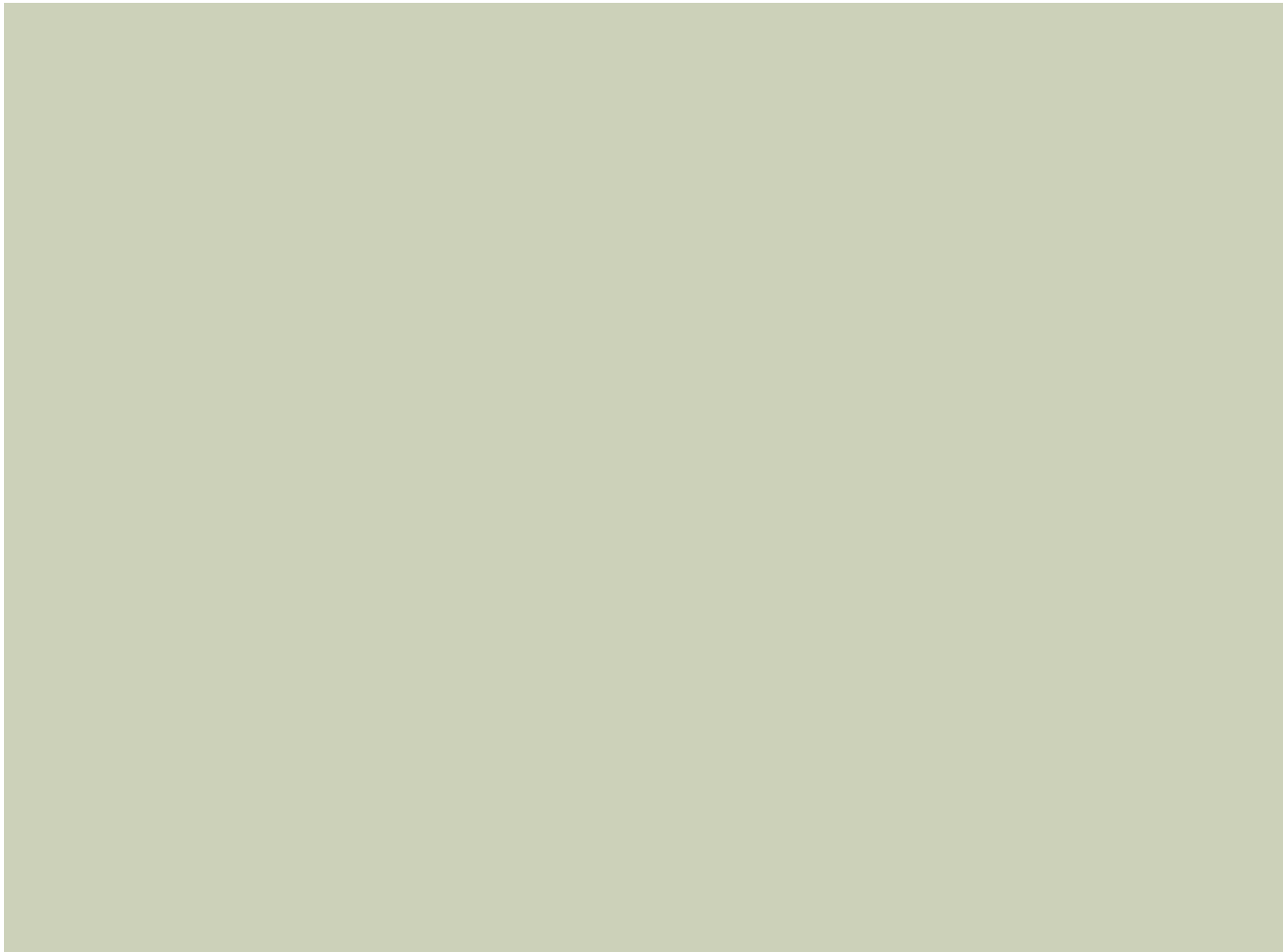
Southern  
Methodist  
University

20 May 2015

Power Plays  
Conference

## Acknowledgements:

Heather DeShon, Chris Hayward, Matt Hornbach, Beatrice Magnani, Cliff Frohlich, Jon Olson, North Texas Eqs Working Group, USGS



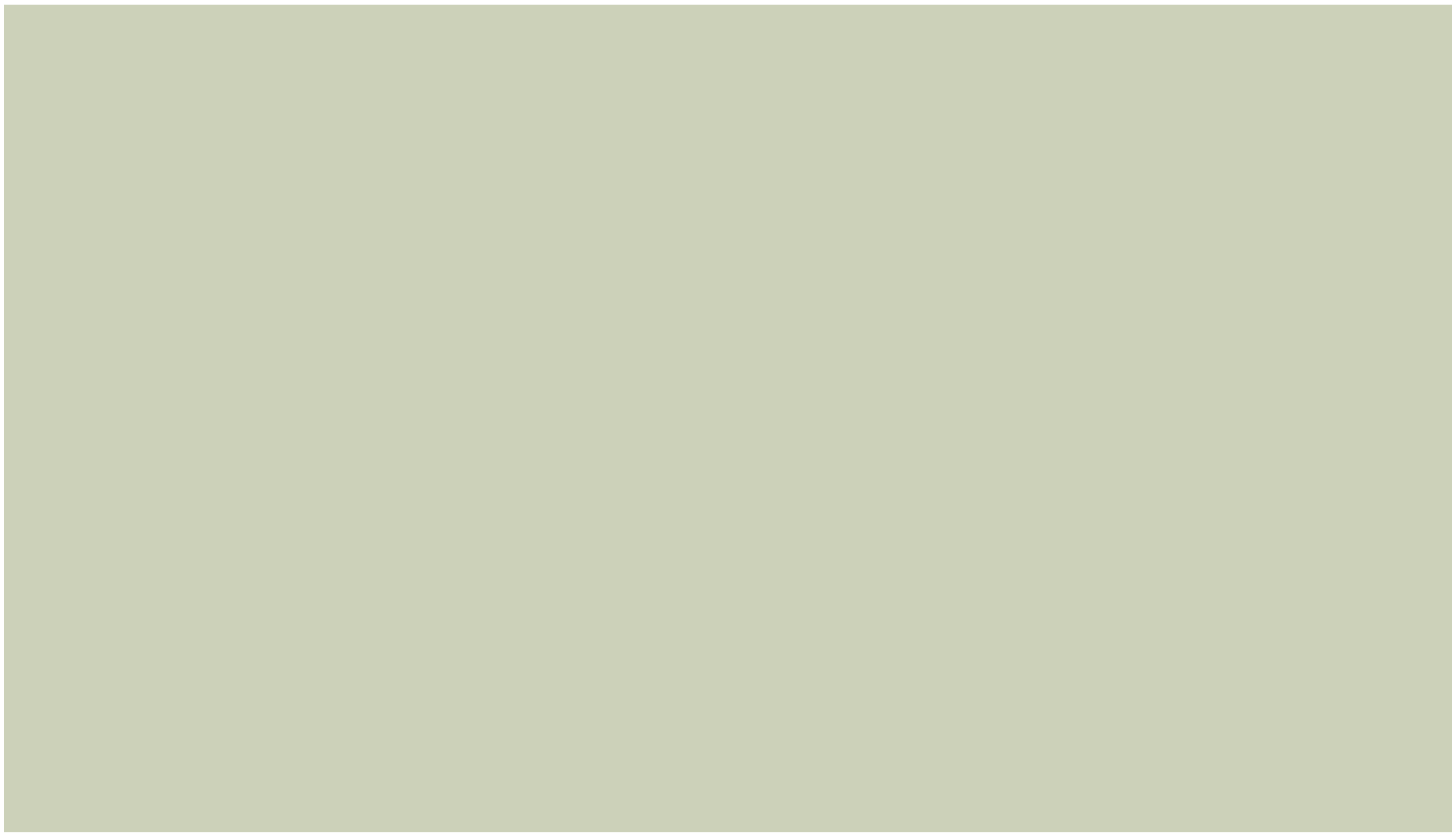
# INCREASE IN SEISMICITY IN CENTRAL AND EASTERN US

Recent increase in annual seismicity in Central and Eastern US Ellsworth, 2013.

[earthquake.usgs.gov/research/induced/](http://earthquake.usgs.gov/research/induced/)

Incorporating Induced Seismicity in the 2014 United States National Seismic Hazard Model  
Results of 2014 Workshop and Sensitivity Studies

[Pubs.usgs.gov/of/2015/1070/](https://pubs.usgs.gov/of/2015/1070/)



NATIONAL RESEARCH COUNCIL REPORT  
INDUCED SEISMICITY POTENTIAL IN ENERGY  
TECHNOLOGIES, 2012





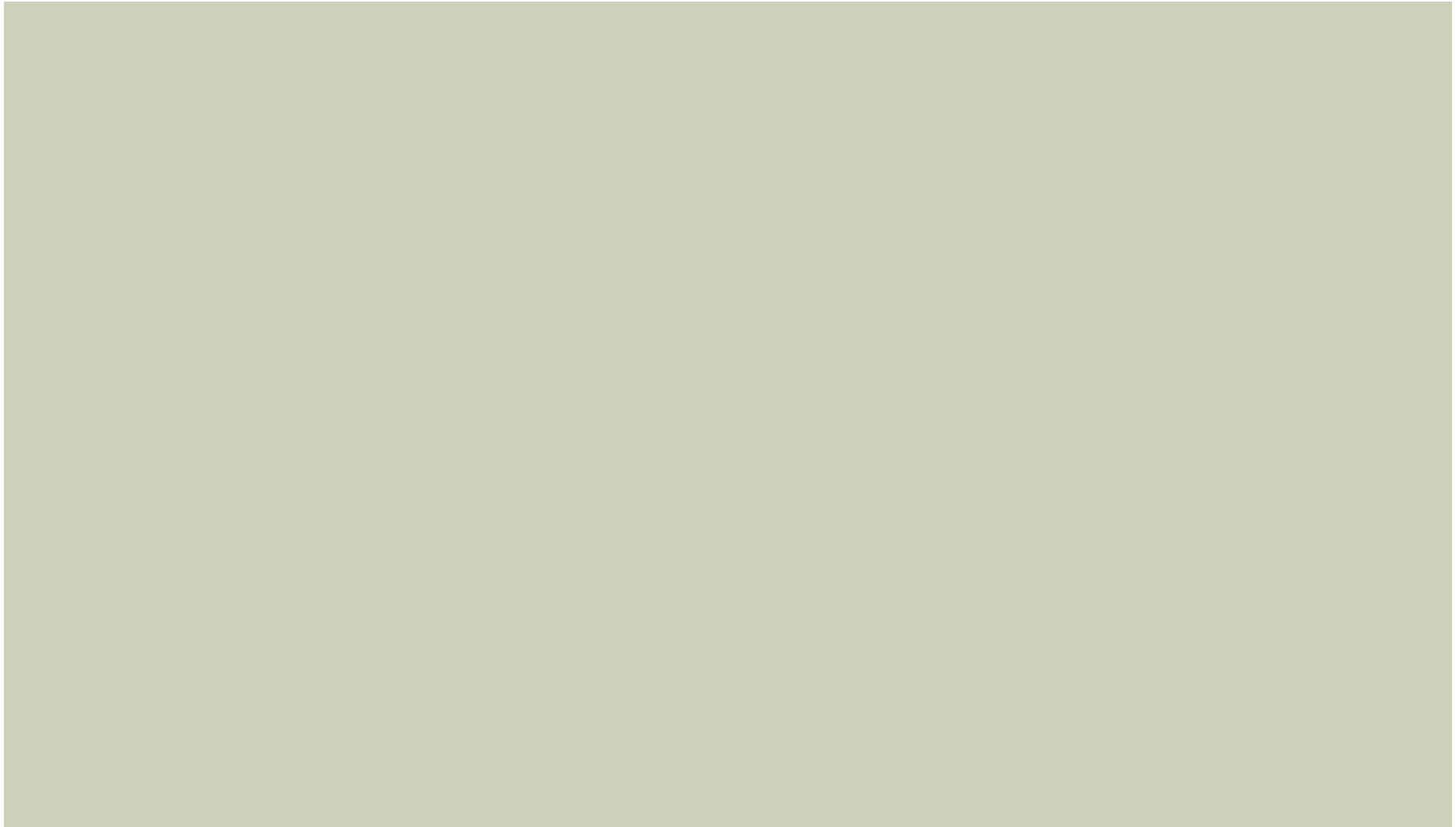


RMA CONCLUSION: THE PRESSURE OF THE FLUIDS  
LOWERED THE FRICTIONAL RESISTANCE ALONG AN  
EXISTING FAULT SYSTEM



# Development of Shale Plays in Central and Eastern US

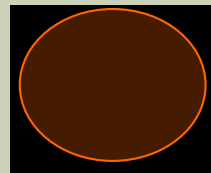
# Oil and Gas Recovery from Shale Can Include Hydraulic Fracturing, Production and Waste



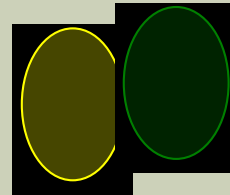
# 1 Earthquake in Fort Worth Basin prior to 2008 & over 160 since



May 20, 1950: One felt report, no instrumental data



Azle

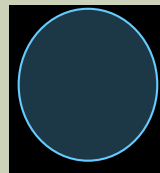


Irving

DFW Airport



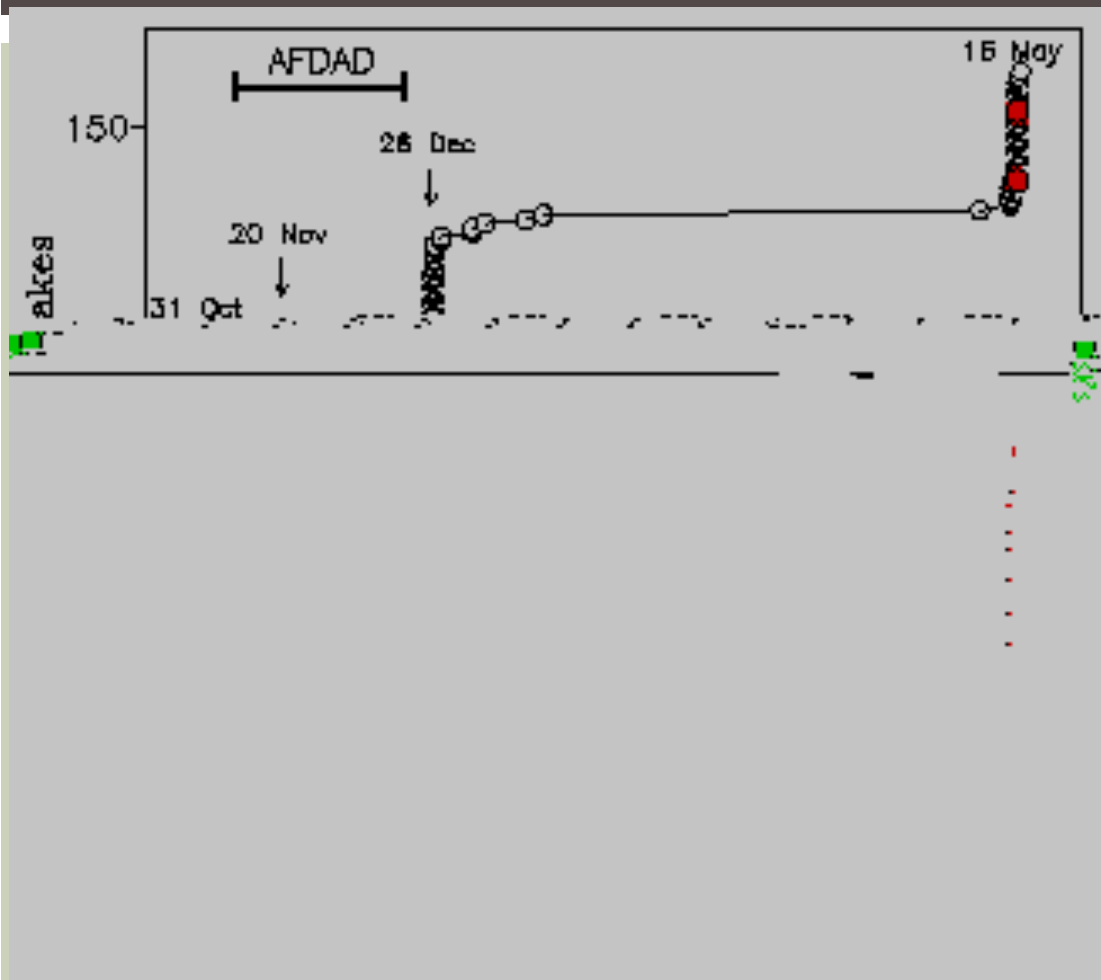
Venus



Cleburne

# DFW EARTHQUAKE SEQUENCE

31 October 2008 ÷ First Felt EQ in Recorded History



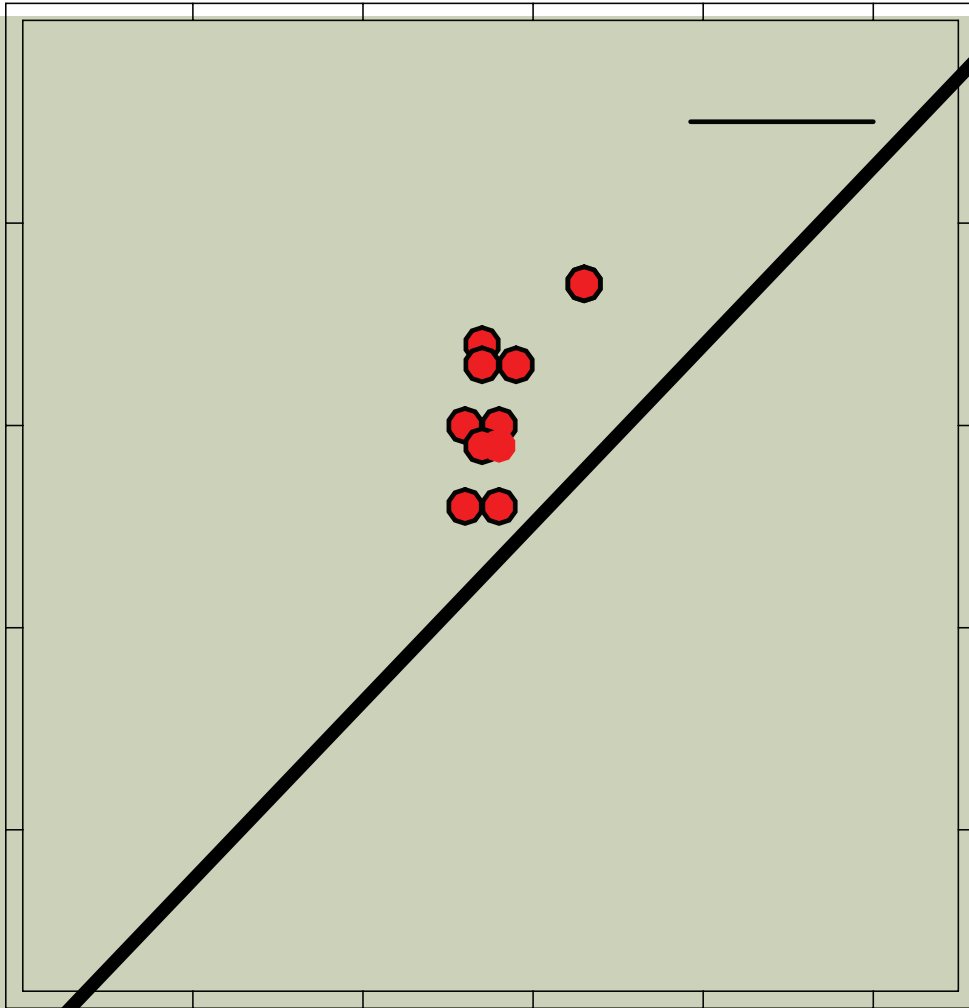
Most Sensitive Station is WMOK,  
in Oklahoma at 280 km



- ! USGS located 14 events but over 150 events identified using the sensitive station WMOK
- ! No events before 31 October 2008
- ! Ongoing sequence motivated a deployment of local instruments to improve locations

First Earthquake Sequence Begins ÷ Recorded by seismometers hundreds of kilometers from the event

# Portable Network of Seismometers Deployed to Improve EQOs Locations



Refined Locations Provided Opportunity to  
ExpeTuQ C-13(au)-13()-13( of Ea)-320t

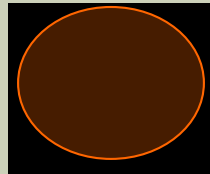
# Texas Railroad Commission Disposal Well Data

- ! Earthquakes located within hundreds of meters of disposal well
- ! Earthquakes began shortly after the injector was initiated
- ! A mapped fault crosses the area
- ! No subsurface data on geology or material properties was made available
- ! Earthquakes continued into 2010 and moved away from injector

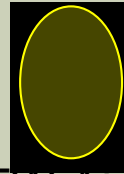




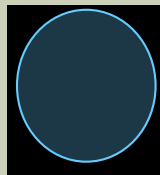
# AZLE Earthquake Sequence 2014-2015



Azle



DFW Airport



Cleburne

Industry Cooperation in Study

# AZLE EVENT LOCATIONS THROUGH 26 AUG, 2014

!! The last widely felt event was Jan 28<sup>h</sup>, 2014

!! Seismicity rate was highly variable

!! The sequence has slowed, last recorded event January 2015

!! Faulting appears complex

# CAUSAL FACTORS

- ! Natural Tectonic Stress Changes

- ! Ground Water



<1 kPa on  
the fault

- ! Changes

- ! Industry Activity
  - ! SWD Injection
  - ! Brine Production

# SWD INJECTION AND BRINE PRODUCTION MOST LIKELY CAUSE

- ! Pressure modeling confirms it is plausible injection/production caused pressure changes sufficient to trigger earthquakes.
- ! Pressure modeling indicates pressure changes associated with drought were orders of magnitude lower
- ! Faults near Azle/Reno area though historically inactive, appear near-critically stressed
- ! Currently, industry activities appear to represent the largest quantifiable stress driver on the fault system.

# LINKAGE TO PRODUCTION ACTIVITIES

Questions from Davis and Frohlich, 1993	Cleburne Answers
1. Are the events the first known earthquakes of this character in the region?	YES
2. Is there a clear correlation between injection and seismicity?	YES
3. Are epicenters within 5 km of wells?	YES
4. Do some earthquakes occur at or near injection depth?	YES
5. Are there known geologic structures that may channel flow to sites of earthquakes?	YES
6. Are changes in fluid pressure at well bottoms sufficient to encourage seismicity?	YES
7. Are changes in fluid pressure at hypocentral distances sufficient to encourage seismicity?	YES

# EVENTS CONTINUE

Magnitude 3.3 (18 May) and 4.0 (7 May)

# PATH FORWARD

## NRC, 2012

Current models employed to understand the predictability of the size and location of earthquakes through time in response to net fluid injection or withdrawal require calibration from data from field observations.

**The success of these models is compromised in large part due to the lack of basic data at most locations on the interactions among rock, faults, and fluid as a complex system.**

**!! Proof of Induced Seismicity may be difficult to obtain.** Absolute proof may not be necessary for consideration of prudent operational changes.

**!! No agreed upon physical model for linkage between commercial activities and earthquakes.** A range of physical models may be in operation depending on individual conditions.

**!! Need for reservoir engineers, geologists and geophysicists to work together to attack these problems.** Data sharing provides a step in assessment of these issues. Seismic monitoring is only one part of this assessment.



Data collected in real-time  
and made publically  
available

[smu.edu/News/NewsIssues/  
EarthquakeStudy/](http://smu.edu/News/NewsIssues/EarthquakeStudy/)